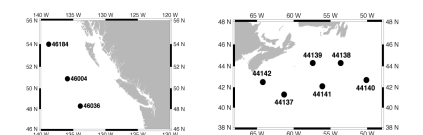


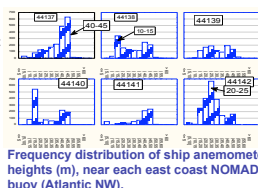
## INTRODUCTION

Homogenous marine winds are needed for atmosphere, ocean, wave, and climate modelling, for trend and variability analysis, and for verification of remote-sensed near-surface winds. Ship and buoy winds are inhomogeneous. The greatest source of bias in measured winds is the difference in anemometer heights (Thomas *et al.* 2004). The Lindau (1995)-adjustment for estimated winds had less impact on the mean bias between estimated and buoy winds. We examine height-adjusted measured winds and estimated winds and see other interesting differences in the ship – buoy bias and variability, related to factors such as the recruiting country, vessel type, night/day and heading/following wind conditions. We use coincident ship and NOMAD buoy reports, from 1980 to 1995. The goal is to understand how to correct for these effects and improve the marine wind climate record.



## HEIGHT ADJUSTMENT

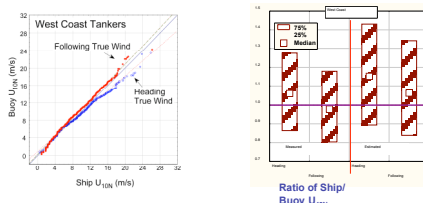
Anemometer heights were 5 m, moored buoys; 20 to 25 m, small ships such as fishing vessels, coast guard ships, and research vessels; and 30 to 40 m, merchant vessels. Winds increase logarithmically with height in the surface layer (9% from 5 m to 10 m, 10% from 10 m to 25 m, and 16% from 10 m to 40 m, for neutral stability). We adjusted measured winds to 10 m effective neutral using similarity theory.



- Different recruiting countries showed different preferred values:
- US estimated winds, nearest 5 knots;
  - German estimated winds, mid-point of the Beaufort intervals;
  - US measured winds, nearest 5 knot and even knots;
  - Japanese measured winds, more continuous;
  - Canadian government vessel measured winds, 5 knots (not shown).

## HEADING OR FOLLOWING WIND

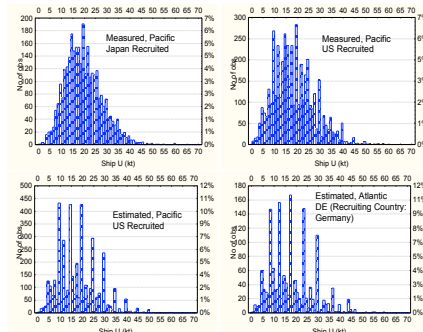
The ship heading relative to the true wind (and perhaps wave) direction seems to affect the reported wind. This may be due to the influence of waves, to errors in determining the true wind from the apparent wind, or may result from differences in relative wind direction. In this study, the ship course and the buoy wind direction were used to determine whether the true wind was coming from ahead or astern of the ship's beam (sides). For heading true winds, most relative winds are on the bow or forward quarters of the ship. The following wind category includes a wider range of relative wind directions.



- Ship winds, both measured and estimated, were higher with a heading (true) wind, than with a following wind, by 10% for measured and 15% for estimated winds.
- Tanker winds show good agreement with buoy winds up to about 14 ms<sup>-1</sup>. For stronger winds, heading winds were reported as higher than buoy winds and following winds were reported as lower.

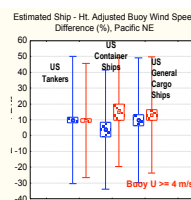
## RECRUITING COUNTRY

There were more measured than estimated winds; the proportion of estimated winds decreased over the period. Most estimated winds on west coast were from US recruited ships; on the east coast most were from US, German, and British ships. Frequency histograms of original reported winds show differences in preferred speeds, depending on wind method and recruiting country.



## NIGHT OR DAY TIME

At night or in poor visibility, it is more difficult to visually estimate winds based on waves. Some ships use anemometers for aid. Do observers adjust for height or for ship motion?



- Estimated winds from container and general cargo ships showed a night/day variation, with bias increasing in the day by 5 to 15%.
- Estimated winds from US tankers and British bulk carriers did not show an overall night/day variation.
- Measured winds from German container ships showed a higher bias by day.

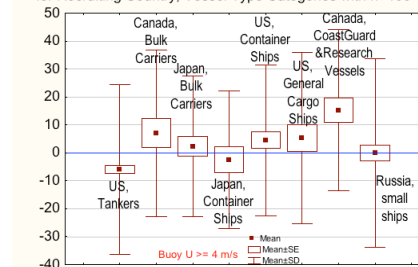
## SHIP TYPE

Typical ship types and sizes near the buoys differed by location. Shipping lanes near some buoys resulted in many reports from merchant vessels. Tankers provided the majority of observations, of the identified ship types. Other main merchant vessel types were container ships, general cargo vessels and bulk carriers. Smaller Coast Guard and research vessels, provided many east coast reports. Ship types for many reports were not identified.



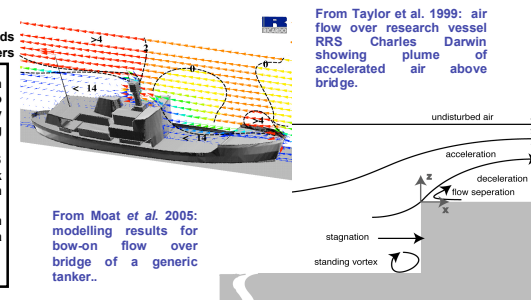
Frequently reporting large merchant vessels in the VOS fleet: tankers, bulk carriers, container vessels, and general cargo ships.

Measured Ht. Adjusted Ship - Buoy Wind Speed (%), Pacific NE, for Recruiting Country, Vessel Type Categories with n>100



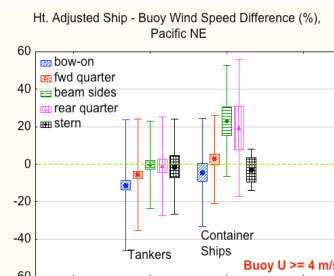
- The percentage difference between the buoy winds and those measured by co-located ships of different types and from different countries varies both in sign and in magnitude
- Winds from small Canadian Vessels (Research and Coast Guard) are consistently about 15% higher than buoy winds, even after adjustment for height
- In contrast the winds from US tankers are consistently about 5% lower than the buoys

## AIR FLOW DISTORTION & RELATIVE WIND DIRECTION



Different vessel types have different flow distortion characteristics. Air flow distortion patterns will vary as the wind comes from different directions around the ship. Can we learn anything about air flow distortion by looking at ship/buoy wind speed differences for a range of relative wind directions, for different ship types?

The Figure below shows that the percentage difference between ship and buoy winds varies with ship type and relative wind direction. Bow-on winds for both container ships and tankers are lower than the co-located buoy winds. For container ships the winds on the beam and on the rear quarter are around 20% higher than those from the buoys. More work is needed to confirm these interesting results.



Difference in Ht. Adjusted Ship - Buoy Wind Speed (%), for Tankers and Container Ships, Pacific NE, Binned on Platform Relative Wind Directions Ranging from Bow-on Flow around to the Stern.

## CONCLUSIONS

Differing observation practices between VOS recruiting countries, heading or following wind conditions, time of day, ship type, and platform relative wind direction contribute to bias and variability in ship winds. More work is needed to understand these effects. We plan to extend the dataset to include more recent data with more complete metadata and investigate application to ICOADS, the International Comprehensive Ocean-Atmosphere Dataset.

## REFERENCES

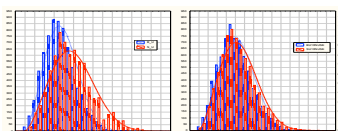
- Lindau, R., 1996: A new Beaufort equivalent scale. *Proc. Of Int'l COADS Winds Workshop*, 31 May - 2 June 1994, Kiel, Germany, (Kiel: Institut für Meereskunde/Christian-Albrechts-Universität), pp. 232-262.  
Moat, B. L., M. J. Yelland, R. W. Pascal and A. P. Moland, 2005: An overview of the airflow distortion at anemometer sites on ships. *Int'l J. Clim.* (CLIMAR-II Special Issue), 25(7), 997-1006.  
Taylor, P. K., E. C. Kent, M. J. Yelland, and B. L. Moat, 1999: The Accuracy of Marine Surface Winds From Ships and Buoys. *CLIMAR II: Wind Workshop on Advances in Marine Climatology*, Vancouver, 8 - 10 Sept. 1999, pp. 59-68.  
Thomas, B. R., E. C. Kent and V. R. Swail, 2005: Methods to Homogenize Wind Speeds from Ships and Buoys. *Int'l J. Clim.* (CLIMAR-II Special Issue), 25(7), 979-995.

## ACKNOWLEDGMENTS

The authors acknowledge the contribution made by VOS observers, Port Meteorological Officers, and Meteorological Service of Canada Buoy Specialists to the existence of these observations. The Marine Environmental Data Service, of the Canadian Department of Fisheries and Oceans, and the ICOADS group provided archived reports. The Program of Energy Research and Development provided financial support.



Adjustment factors for anemometer heights of typical marine platforms (to adjust to 10 m assuming neutral stability and a logarithmic profile).



Measured ship (red) and buoy (blue) wind speed distributions, before and after adjustment for anemometer height and buoy averaging method.